The shaded portion of this chart marked AA shows the comfort area as embodied into the New South Wales law. This law, apparently, does not permit much deviation from these dew-point readings, and does not limit air movement as a function of cooling, although it must be recognized that velocity of air is an important point in furnishing comfort.

It is also evident that the employees require higher temperatures for light sedentary work, than they do for heavy work in which much muscular exertion is necessary.

According to Pierce,[2] the air conditions may vary from 63° F. with a humidity of 40 per cent to 90° F. with a humidity of 25 per cent, and still give comfort in the home. This area is marked BB in the chart. Air movement is again omitted from consideration, but race types are mentioned. These conditions are given as optimum for the home and the hospital, but the author shows the impossibility of hard work in conditions outside of the marked comfort area.

If the comfort area, between certain temperature limits, is determined by the formula used by some heating and ventilating engineers, it is that portion marked CC on the chart. The formula is, $R = 316 - 4$ F.—that is, the conditions most favorable are such that the relative humidity in per cent, should be 316 minus four times the dry bulb reading in F. degrees. Air movement is not considered.

The work of Hill[3] has done more, perhaps, to initiate a scientific study of optimum atmospheric conditions than any other report. A number of interesting articles[4] have appeared.

In most of these articles the principle of the kata thermometer is used. The dry kata cools by radiation and by convection, the wet kata by these and by evaporation in addition. The most satisfactory condition as agreed upon by Hill and his followers in kata readings are here given: For sedentary work a dry kata reading of 6 millicalories and a wet kata reading of 18. For light manual work the readings should be 8 and 25, and for heavy manual work, 10 and 30, respectively. The chart has a wet kata scale in horizontal dots and dashes, and a dry kata scale in vertical dots and dashes. The 6 to 18 area is designated by D.

These instruments, especially the wet kata, are affected by air currents, so that temperature, humidity, and air velocity all function in the results.

The human body, however, is perhaps never a dry kata as far as its surface is concerned, and seldom, if ever, does it become exactly comparable to a wet kata. The use of these instruments, however, has opened up new methods of dealing with questions concerning problems of heating and ventilation.

As one views the accompanying chart, he wonders why these areas, determined as they are to locate comfort areas, should be so far apart. Do the investigators find different answers to the same question? Do the physiologists disagree upon what constitutes comfort? Do racial differences, or geographical locations, cause what is comfort for one set of persons to be discomfort for another set, brought up to live under different climatic conditions?

There remains one more area to notice. Experiments in the laboratories of the Bureau of Mines in Pittsburgh, as shown by investigators from the American Society of Heating and Ventilating Engineers[5] seem to determine comfort lines by making use of bodily sensations of several subjects, and verified by physiological measurements. These lines of equal comfort are shown in the chart by dashed lines. The experiments show the 64° effective temperature line as most comfortable for the light activities in still air. The area is marked EE. Lines for different kinds of work, and for air in motion have yet to be determined.

This area, EE, corresponds only in part with the other four areas determined by different investigators and in different ways. The methods used in determining this last area seem to be purely scientific and accurate, and if pursued to the limit ought to answer some of the questions proposed earlier in this article. Such an experiment involves the use of many subjects of different race stocks, different ages, and different geographical residences, but in time should definitely answer the problem of maximum comfort and degrees of discomfort.

[2] Pierce, W. Dwight. *The Nation's Health*, September, 1922, pp 463–566.

[3] Hill, L.: The Science of Ventilation and Open Air Treatment. *Part II, Medical Research Council, Special Report, Series No. 52*, London, 1920.

[4] Orenstein and Ireland: Experimental Observations upon the Relation of Atmospheric Conditions and the Production of Fatigue in Mine Laborers. *The Journal of Industrial Hygiene*, May, 1922, pp. 30 et seq., followed by a continuation in the June number, pp. 70 et seq.

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[5] Houghten and Yagloglou: *Journal of the Society of Heating and Ventilating Engineers*, 1923.

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THE HIGH-ALTITUDE ROCKET

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A recent request by the editor of the Monthly Weather Review for a statement on the rocket development gives a welcome opportunity to present first hand the aims and results of the investigation.

The work at present being carried on is the development of a small model which will have a sufficient vertical range to demonstrate clearly the correctness of the principles that are involved. The propellant consists of liquids, first suggested publicly in 1914, and tested experimentally in 1921, it having been found possible in this way to obtain propulsive force without excessive heating.

After a satisfactory demonstration of this model has been made, the next step, which, it is hoped, will be sufficiently supported financially, is the exploration of the atmosphere in the wide unknown region extending upward from 30 km. to 750 km. (20 to 460 miles). Among the interesting matters to be investigated in this region are whether or not the conclusions from meteoric studies are correct, that the upper limit of the stratosphere is at 60 km. (37 miles), where the temperature rises from $-53°$ C. to 27° C., in a region of ozone, or the conclusions from auroral studies are correct, that the upper limit is at 90 km. (56 miles), where the temperature falls, there being a region above consisting largely of nitrogen at a temperature below 60° A., and extending upward for hundreds of kilometers. In this connection it should be stated that Prof. W. J. Humphreys, of the United States Weather Bureau, has suggested a very simple and clever means of carrying out the most difficult of the measurements, namely, that of temperature.

A further question of interest which may be asked is, To what extent does the moon figure in this rocket investigation? It should be understood, first, that calculations for minimum initial mass of rocket, which take account of both air resistance and gravity, have shown that, for an average velocity of ejection of gases from the rocket of 12,000 ft./sec., an initial mass of rocket of but 40 pounds is necessary for each pound mass given a sufficient velocity (acquired far above the dense part of the atmosphere) to escape from the earth's predominating gravitational attraction. Actual laboratory tests have produced an average speed of ejected gases of closely 8,000 ft./sec., and results from tests *in vacuo* indicate that this corresponds to a speed of 9,700 ft./sec., *in vacuo*. There is every reason to believe, from results so far obtained and from well-established theory, that a sufficiently high velocity can be secured, with a rocket which consists chiefly of propellant material.

The object of the work is, however, much more than the performance of some single spectacular stunt. It is the development of a new method, and although experience has shown that it is hopeless to discuss publicly all the matters which have been studied, both theoretically and experimentally, it is confidently predicted that this method will lead to achievements of the very greatest interest, which can almost certainly be realized in no other way.

New methods are usually slow of development, but it would be well worth while if the means were at hand to make an attack simultaneously upon all the problems connected with this investigation.

BIBLIOGRAPHY OF DR. W. DWIGHT PIERCE'S CONTRIBUTIONS ON METEOROLOGICAL EFFECTS ON LIFE

Dr. W. Dwight Pierce, consulting research director, Banning, Calif., has, during the last two years, published numerous articles dealing with physiological effects of air conditions. In response to a request Doctor Pierce has prepared the following bibliography of his papers, covering meteorological effects on life. Since most of the publications referred to are not usually brought to the attention of meteorologists, the publication of this bibliography should be of value to those studying the biological effects of air conditions.—*C. F. B.*

1. Some factors influencing the development of the boll weevil. Proc. Ent. Soc. Washington, vol. 13, pp. 111–114, discussion 114–117, June 19, 1911.

2. The insect enemies of the cotton boll weevil. W. Dwight Pierce, R. A. Cushman, and C. E. Hood, in U. S. Bureau of Entomology, Bul. 100, pp. 1–99, April 3, 1912. (3 plates, 26 figs.)

3. Mexican cotton boll weevil. W. D. Hunter and W. Dwight Pierce, Senate Document 305, 62d Congress, 2d session, pp. 1–188, 22 plates, 34 figs., April, 1912.

4. Note on temperature control. Proc. Ent. Soc. Washington, vol. 14, p. 87, June 19, 1912.

5. Note on classification of temperatures. Proc. Ent. Soc. Washington, vol. 14, pp. 101, 102, June 19, 1912.

6. A new interpretation of the relationships of temperature and humidity to insect development, Journ. Agric. Research, vol. 5, No. 25, pp. 1183–1191, figs. 1, 2, March 20, 1916. Abstracted in Mo. WEATHER REVIEW, U. S. Dept. of Agric., vol. 47, No. 7, July, 1919, pp. 494–495.

7. The relations of climate and life and their bearings on the study of medical entomology, in Sanitary Entomology (Richard G. Badge, publ., Boston, Mass., edited by W. Dwight Pierce), ch. 6, pp. 97–104, March 6, 1921.

Doctor Pierce says: "These articles trace the beginnings of the philosophy in my lecture on 'The Laws of Nature as Affecting Insect Abundance.'"

8. Air conditioning in hospital sanitation, printed in *The Nation's Health*, vol. 4, No. 7, pp. 444–446, July 15, 1922, and reprinted as "Bringing Climate to the Patient" in *The Modern Hospital*, vol. 19, No. 3, pp. 199–202, September 1, 1922; reviewed in *Literary Digest*, February 10, 1923, p. 27.

9. Air conditioning, longevity, and health, *The Nation's Health*, vol. 4, No. 9, pp. 563–566, September 15, 1922.

There is a series of articles running in *The Western Florist, Seedsman and Nurseryman*, printed in Los Angeles (315 South Broadway) on similar lines as applied to the plant: "Treating the plant as a living being" (April, 1923); "Nursery and greenhouse sanitation" (July, 1923); "Tackling difficult problems" (September, 1923); "Climate and the plant" (December, 1923); "Problems the date growers are trying to solve" (January, 1924).

10. The bearing of climate laws on plant and animal activity, appeared in *The Fruitman* (S. F.) Sept. and Oct., 1923.

WATERSPOUT AND TORNADO WITHIN A TYPHOON AREA

551.515 (51)

By Prof. GEORGE B. BARBOUR

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A tornado in north China is sufficiently rare to merit comment, especially if it chooses its path right through the center of the principal summer resort of the entire foreign community north of Shangtung. Peitaiho Beach (39° 48′ N. lat., 119° 30′ E. long.) owes its popularity to the fact that it is the first point along the coast east of Tientsin where bedrock is exposed; all the shore to the west is part of the delta formation of the Bay of Peking upon which Tientsin itself is built.

On the afternoon of August 11, a tornado struck the shore and went inland crossing the foreign settlements at its widest point, seriously damaging all the buildings in its track. It showed the characteristics of those in more southerly latitudes. By good fortune the Italian gunboat *Sebastiano Caboto* was anchored almost in its track, and I am indebted to the careful observations of Capt. G. Viganoni for records he has most generously supplied. Also without the cooperation of Mr. R. D. Goodrich, jr., of Tientsin, I should have been entirely unable to secure other data regarding the occurrence.

Local opinion blames the "extra fifth month" intercalated in 1922 with the abnormal weather experienced since that date. In any case the winter and spring were the mildest in 15 years, the summer less hot and the period of autumn rain showers more than usually protracted. The general weather conditions have been unsettled and the damage by typhoons appears comparatively severe, though this latter is not so easy to estimate.

On August 10 the observatory at Siccawei [Zi-ka-wei] near Shanghai had simultaneous warnings out for two typhoons, one being eventually signaled from latitude 28° N. and longitude 122° E.

At 6 a. m. on the 11th it was reported moving north and described as of extreme violence. The local barometer readings at Peitaiho had stayed at 760 mm. (29.92 inches) until the afternoon of the 10th when the sky became overcast. Heavy rain fell during the latter hours of the night, the wind veered from southwest to northeast with the barometer steady at 759.5 mm. (29.90 inches.)

Soon after 1 p. m. the barometer began to fall, the wind veered sharply to west-southwest and increased to 25 f. p. s. (17 m. p. h.). Rain fell all afternoon with increasing violence, passing into a severe thunderstorm. A few minutes after 4 p. m. a brilliant flash of lightning was accompanied by a particularly loud thunderclap that shook the entire settlement.

At the same time about three-quarters of a mile out to sea, the formation of a whirl could be clearly seen.